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EFFECTS OF COMBINED ORGANIC/INORGANIC FERTILIZER APPLICATION ON GROWTH, CHEMICAL COMPOSITION, YIELD AND QUALITY OF GRANDE NAINE CV. BANANA PLANTS

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ABSTRACT

Application of organic fertilizers and reduction of mineral fertilizers are economically feasible and environmentally sound approaches to develop sustainable agriculture. Field experiments on banana cv. Grand Nain for two consecutive seasons (2018 and 2019) were conducted at a private orchard located at Badaway, Al-Dakahlia governorate, Egypt. The main objective of this study was to investigate the possibility of reducing the mineral fertilizers applied to the banana crop by using organic fertilizers and natural compounds (Humic and Amino Acids). Two rates of the recommended rate of mineral fertilizers (RMF): 50 and 75% were applied with 25kg Compost along with or without 100g Humic and 100g Amino Acids per mate. These treatments were compared with the control 100% RMF. Results showed that the application of RMF different rates with Compost, Humic and Amino Acids recorded a positive effect on growth, yield and fruit quality of banana. The treatment T3= 75% of recommended mineral fertilizers + Humic acid (100g/mate/year) + Amino acids (100g./mate/year) + Compost (25 kg./mate/year) recorded the uppermost values of growth, yield and quality of banana fruits. It can be concluded that treating Grande Naine cv. banana plants with mineral fertilization (N, P and K) combined with Compost, Humic and Amino acids as soil application were the best treatments for improving growth, NPK content, yield and fruit quality.

Keywords: Banana, Compost, Humic, Fertilization, Yield, Quality, Grande Naine.

1. INTRODUCTION

Banana (*Musa spp*.) is the fourth most important fruit crop after grape, citrus and mango in Egypt. It is being cultivated in 18.571 ha with a total annual production of 1.3 million tones according to the statistics of Egyptian, Ministry of Agriculture and Land Reclamation (Bulletin of the Agricultural Statistics, 2019). The usage of organic fertilizers and natural compounds such as Humic, and Amino Acids have gained momentum as a substitute to chemically synthesized fertilizers due to its reported effectiveness, the increasing cost of some chemical fertilizers and the awareness towards the hazardous effects of chemical fertilizers to human healthy and the environment (Ayalew and Dejene, 2012).

The combined use of chemical and organic fertilizers resources in turn will reduce the total reliance on chemical fertilizers while maintaining good soil fertility and high yield levels. Earlier studies by Chivenge et al. (2011) and Ripoche et al. (2012) indicated that combined applications of organic and chemical fertilizers consistently resulted in the highest banana yields, relative to organic or chemical fertilizers alone. Abd ElMoniem et al. (2008) and Barakat et al. (2011) reported that the combined application of organic

fertilizers and chemical fertilizers increased soil Nitrogen, Phosphorus (P) and Potassium availability and decreased soil pH compared with the treatments with chemical fertilizers alone of banana plants. Moreover, Amin et al. (2016) found that soil application of both Amino acids and Humic together on Grande Naine banana plants could improve the banana yield and its components.

The objective of this research was to assess the impact of reduced dose of mineral fertilizers supplemented with organic fertilizers on the growth, yield, chemical composition concentration and fruit quality of banana Grande Naine cultivar under clay soil conditions in Egypt.

2. MATERIAL AND METHODS

2.1. Study Site

These investigations were conducted on third sucker of 2 and 3 Grand Nain banana rations grown in clay loamy soil of banana plantation belong to a private orchard located at Badaway, Al-Dakahlia governorate, Egypt (latitude 31.05 ˚N, longitude 31.38 ˚E, and 2.89 m above sea level), during 2018 and 2019 experimental seasons. Some physical and chemical properties of the used soil were determined according to Jackson (1973) are shown in table 1. The plantation holes (Mats) were 3 * 3.5 m with three productive rations (three suckers were selected and kept to grow for consecutive cropping).

Table 1: Physical and chemical characteristics of the experimental soil site at the beginning of experiment 2017.

Properties	Values	Properties	Values
Sand (%)	27.6	**Ca^{2+} mg/kg soil**	331.1
Silt (%)	31.5	**K^{+} mg/kg soil**	427.2
Clay (%)	40.9	**Na^{+} meq/l**	13.71
Texture class	Clay- loam	**Mg^{2+} mg/kg soil**	1203.31
Organic matter %	1.02	**P mg/kg soil**	3.32
CaCO3	17.2	**Cl^{-} meq/l**	17.62
pH(1:2.5 extract)	7.6	**$SO4^{-1}$ meq/l**	39.11
E.C. (dSm^{-1})	1.3	**Zn mg/kg soil**	0.95
Total N mg/kg soil	99.7	**Fe mg/kg soil**	24.47

2.2. Compost Used (Plant And Animal Wastes)

Compost was added and mixed with soil in preparation stage at 25 kg./mate (equal 9 tons/fed.). Table 2. shows some physical and chemical properties of used compost.

Table 2: Some physical and chemical characteristic of used compost**.**

Characteristic	Values
Weight of m^3(kg)	573
Humidity %	24.86
pH	8.4
E.C.dS.m^{-1}	4.67
Total nitrogen %	1.52
Organic matter %	38.22
Organic carbon %	22.15
Aches %	77.11
C/N ratio	19.4
Total phosphorus	0.82
Total potassium	0.87
Fe ppm	382.2
Mn ppm	66.1
Cu ppm	28.15
Zinc ppm	49.21

2.3. Humic Fertilizer Analysis

Humic acid 75%, potassium (K_2O) 10%, Volvic acid 4% and Fe 2%.

A complete block design with three replicates containing five treatments was used as follows:

T1= 100% of recommended mineral fertilizers application (RMF) 600, 100 and 500 kg./fed. of N, P_2O_5 and K_2O, respectively) as a control.

T2= 75% of recommended mineral fertilizers+ Humic acid (100g./mate/year) + Amino acids (100g./mate/year).

T3= 75% of recommended mineral fertilizers + Humic acid (100g/mate/year) + Amino acids (100g./mate/year) + Compost (25 kg./mate/year).

T4= 50% of recommended mineral fertilizers + Humic acid (100g/mate/year) + Amino acids (100g./mate/year).

T5= 50% of recommended mineral fertilizers+ Humic acid (100g./mate/year) + Amino acids (100g./mate/year) + Compost (25 kg./mate/year).

Nitrogen (N) doses were added monthly at 7 equal doses, from the beginning of April until October through the two seasons of the study according to, Potassium (K_2O) doses were added at four equal batches on April, June, August and October (Mostaf, 2005), Humic acid and amino acid doses were added into four doses equal as a liquid suspension during the first week of April to July for each seasons (Amin et al. 2016). While, phosphate (P_2O_5) was added in combinations with the compost at preparation stage in December mixed with soil (Abdel Gawad et al. 2016).

Response of banana plants to different treatments were investigated based on the following parameters;

2.4. Vegetative Growth Parameters

After inflorescence emergence, some vegetative growth parameters were measured as following:

Pseudostem height in cm was measured from the soil surface to junction of the first leaf. Pseudostem circumference in cm which measured at 20 cm. above the soil surface. Leaf area (m^2): The area of the third full sized leaf (from the top) was calculated in m^2 using the following equation: leaf area (m^2) = length × width × area coefficient, area coefficient of Grand Nain banana = 0.86 according to (Murry 1960). Total no. of green leaves/plant at bunch shooting stage, (number of green leaves presented per plant was recorded).

2.5. Nutritional Status (NPK)

Leaves samples of one leaf was collected from every Pseudostem during each season. They were dried in the oven at 70 °C until constant weight and then ground by using a manual mill 0.2g. The ground material was digested using a mixture of 1:10 percholoric and sulphoric acid (v√v) for 15 minutes until the digestive solution became color-less and then transferred quantitatively to 50 ml volumetric flask. Total nitrogen (N %), phosphorus (P %) and potassium (K %) were determined according to Page et al. (1982).

2.6. Time From Bunch Shooting To Harvesting

Duration needed from bunch shooting till harvesting (Maturation) in days was calculated.

2.7. Yield And Bunch Parameters

At harvesting time, Bunch weight (kg), hand number/bunch, finger number/bunch and yield (ton/fed.) were estimated. Yield (t/fed.) was calculated according to the following equations: Yield = Bunch weight (kg) × Number of bunches (1200 plants/fed.)/1000.

2.8. Fruit Quality Parameters

Banana bunches for every treatment were harvested at green maturity stage and held 24 hours in the laboratory at room temperature. Bunches were divided into hands, washed with tap water and air dried then packed in plastic boxes and placed on shelves in ripening room at 20 ±2°C and 90 ±2% relative humidity. Samples were subjected to acetylene gas generated from calcium carbide (5 gm calcium carbide in boiling water m^3 ripening room) for 24 hours then transferred to be held at 15 ± 2°C. At 7 days intervals, two hands were taken from the bunch to estimate the following yield, fruit physical and chemical characteristics for each treatment as follows:

Average finger diameter (cm) was measured as physical fruit quality. Freshly prepared juice of banana fruits samples were used for chemical characteristics (total soluble solids TSS%, total acidity%, starch % and total sugars%) determination as described by A.O.A.C., 2005.

2.9. Statistical Analysis

The obtained data in both seasons were subjected to analysis of variance, using Statistix 9.0 program (Analytical Software, Tallahassee, FL. USA). Mean values were compared by the Duncan's multiple range test at 0.05 % level (Duncan 1955).

3. RESULTS AND DISCUSSION

3.1. Vegetative Growth Parameters

Data in table 2 showed that the vegetative growth parameters (pseudostem height (cm), pseudostem circumference (cm), leaf area and number of green leaves per plant and Total no. of leaves/plant) were significantly affected by compost in combination with Humic acid, Amino acids and NPK doses in both seasons. The highest values of vegetative growth parameters were recorded with treatment T3 followed by treatment T5 in both seasons. The lowest values were obtained with treatments T4, T2 and control.

Treatment T3 was the most effective in terms of producing the highest values of pseudostem height (287.7cm), pseudostem circumference (79.75cm), leaf area (2.7m^2), and total number of leaves/plant (16.7).

All of the increases in vegetative growth parameters could be attributed to increased nutrient uptake, particularly nitrogen (Nalina et al., 2009). This fact is also confirmed by Pafli (1965), who reported that increased nitrogen supply to plants at the appropriate time speeds up the uptake of nitrogen, the main constituent of chlorophyll, proteins, and amino acids.

Table 3. Effect of different fertilization treatments on pseudostem height (cm), pseudostem circumference (cm), leaf area and number of green leaves per plant and Total no. of leaves/plant at flowering of Grande Naine banana plants during 2018 and 2019 seasons.

Treatment	Pseudostem height (cm)	Pseudostemcircumference (cm)	No. of green leaves/plant	Leaf area (m^2)
Control (T1)	194.25c	41.25c	9.5c	1.5c
T2	175.5d	36.85d	8.7cd	1.2cd
T3	287.7a	79.75a	16.7a	2.7a
T4	166.35de	30.95de	6.7d	1.0d
T5	262.5b	72.75b	15.6b	2.0b

Averages in the same column followed by the same letter(s) are not statistically different at 0.05% level according to Duncan's multiple range test.

3.2. Nutritional Status (NPK) And Time From Bunch Shooting To Harvesting

Results in table 4 reveled that the control (T1) with 100% RMF induced significant increases of plant N, P and K contents in both two seasons as compared to other tested treatments. The increase in nitrogen, phosphorus and potassium uptake with control may be attributed to the direct addition of nutrients in the form of chemical fertilizers which provide the nutrient to the soil solution in readily available forms. These results are in agreement with Bhargava (1999), who reported that the plants received 100% mineral fertilizers had optimal leaf nutrient concentrations.

Among organic treatments, treatment T3= 75% of recommended mineral fertilizers + Humic acid (100g/mate/year) + Amino acids (100g./mate/year) + Compost (25 kg./mate/year) recorded maximum value of nutrient concentrations of N (4.47%), P (0.66%) and K (5.44%).

All treatments with compost resulted in reduced duration of days from shooting to harvesting days. Treatment T3 has taken minimum number of days for maturing (96 days). In control (100% RMF) recorded 128 days from shooting to harvest. While, organic treatments receded 96.1 to 118 days from shooting to harvest. These results are in agreement with Athani et al., 2009 who reported that application of mineral fertilization (NPK) combined with compost recorded early shooting in banana plants.

Table 4. Effect of different fertilization treatments on leaf nutrient contents (NPK) and time from bunch shooting to harvesting (days) of Grande Naine banana plants during 2018 and 2019 seasons.

Treatment	N (%)	P (%)	K (%)	Time from bunch shooting to harvesting (days)
Control (T1)	6.22a	0.86a	7.92a	128.5a
T2	3.31c	0.47d	3.22d	118.7b
T3	4.47b	0.66b	5.44b	96.1d
T4	2.89d	0. 32e	3.01e	112.8c

T5	4.38ab	0.57c	4.02c	98.7d

Averages in the same column followed by the same letter(s) are not statistically different at 0.05% level according to Duncan's multiple range test.

3.4. Yield And Bunch Parameters

The data pertaining to yield and bunch parameters are presented in table 5 and it is obvious from the obtained data that added compost with RMF exerted a positive influence on yield and bunch parameters. Treatment T3= 75% of RMF + Humic acid (100g/mate/year) + Amino acids (100g./mate/year) + Compost (25 kg./mate/year) recorded highest results of number of hands/bunch, finger number/bunch, bunch weight and yield 14.9, 228.2, 43.1kg and 34.4 t/fed., respectively.

These results are in agreement with Babu Ratan (2006) who reported that the plants with thicker Pseudostem are desirable as they reflect on bunch size and other related characters. Moreover, application of mineral fertilizer in combination with Compost, Humic and Amino acids of compost to the banana plantation improved nutrient availability to the plants, resulting in high yields. Moreover, these results are in agreement with EL-Agamy et al., (2001), Abdel Moneim-Eman et al., (2008), Barakat et al. 2011 and Amin et al., (2016).

Table 2. Effect of different fertilization treatments on yield and bunch parameters: bunch weight (kg), yield (t/fed.), number of hands/bunch and number finger/bunch of Grande Naine banana plants during 2018 and 2019 seasons.

Treatment	Hand number /bunch	Finger number/bunch	Bunch weight (kg)	Yield (t/fed.)
Control (T1)	10.5c	116.0c	14.8c	11.8c
T2	9.5cd	97.4d	12.5d	10.0cd
T3	14.9a	228.23a	43.1a	34.4a
T4	8.6cd	76.56e	10.4e	8.3d
T5	11.4b	198.4b	38.6b	30.8b

Averages in the same column followed by the same letter(s) are not statistically different at 0.05% level according to Duncan's multiple range test.

3.5. Fruit Quality Parameters

Generally, application of RMF different rates with Compost, Humic and Amino Acids recorded a positive effect on fruit quality parameters. Data in table 3 pointed out that the highest results of finger diameter (3.8cm) and finger weight (118.8g), total soluble solids (21.5%), total titratable acidity (0.45%), total sugars (17.7%) and starch (2.3%) of banana cv. Grande Naine were scored by treatment T3, followed in descending order by T5, control, T2 and T4, respectively. These results are in agreement with Abd El-Moniem et al 2008; El-Koly 2010; El-Kafrawy et al 2011; Vazquez-ovando et al. (2012); El-Mehrat et al. (2012); Roshdy (2014); Bakheit and Elsadig (2015) and Amin et al. (2016) who reported that application of compost for Grand Naine banana plants led to enhance fruit quality as compared to untreated treatments.

Table 3. Effect of different fertilization treatments on some fruit quality parameters: Finger weight, finger diameter, total soluble solids (TSS), total titratable acidity, total sugars and starch of Grande Naine banana plants during 2018 and 2019 seasons.

Treatment	Finger weight (g)	Finger diameter (cm)	TSS (%)	Total titratable acidity (%)	Total sugar (%)	Starch (%)
Control (T1)	94.8c	3.1b	16.08b	0.38c	11.2b	1.6b
T2	90.1d	2.8c	13.6c	0.36d	9.8c	1.5b
T3	118.8a	3.8a	21.5a	0.45a	17.7a	2.3a
T4	85.2e	2.7c	12.4cd	0.32e	8.9cd	1.4b
T5	115.8b	3.6ab	19.7ab	0.42b	16.5a	1.8ab

Averages in the same column followed by the same letter(s) are not statistically different at 0.05% level according to Duncan's multiple range test.

4. CONCLUSIONS

Generally, application of RMF different rates with Compost, Humic and Amino Acids recorded a positive effect on growth, yield and fruit quality of Grande Naine banana plants under the experimental conditions. Treatment T3= 75% of RMF + Humic acid (100g/mate/year) + Amino acids (100g./mate/year) + Compost (25 kg./mate/year), seems to be the promising treatment to produce the highest growth, yield and fruit quality of Grande Naine banana plants under the above experimental conditions.

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